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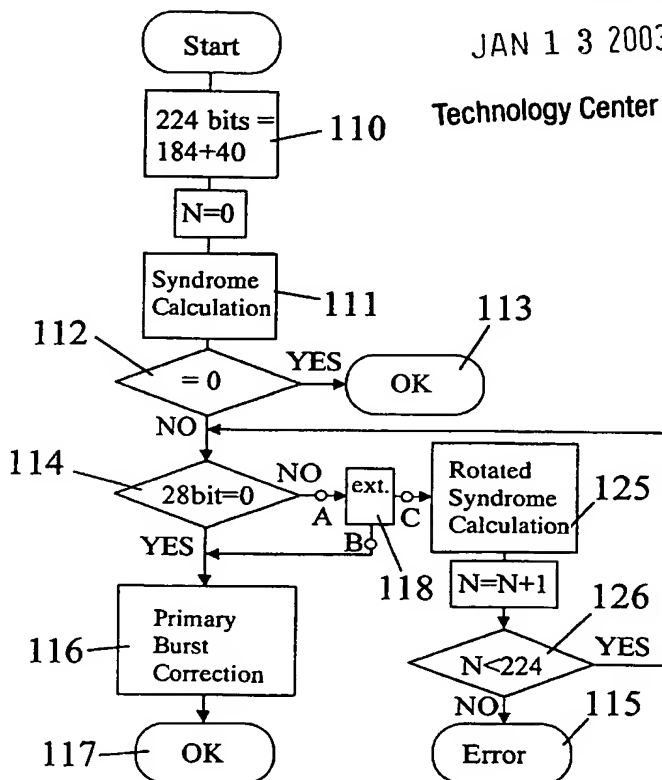
[Continued on next page]

(54) Title: **METHOD AND APPARATUS FOR CORRECTION OF ERRORS IN FIRE CODES USED IN GSM CONTROL CHANNELS**

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(57) Abstract: Method and device for decoding with error correction of a cyclic code signal $r(x)$ containing a main error burst shorter than or equal to a number n and a secondary error shorter than or equal to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions with the cyclic code being a shortened Fire code to supply at most a standard correction of a single burst shorter than or equal to n . According to the method the error burst correction algorithm originally proposed by Fire but modified with the error trapping procedure based on recognition of first k bits of the syndrome generated by the secondary bursts is used jointly.

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INTERNATIONAL SEARCH REPORT

Internal Application No
PCT/EP 00/07308A. CLASSIFICATION F SUBJECT MATTER
IPC 7 H03M13/17 H04L1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H03M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 98 25350 A (ERICSSON GE MOBILE INC) 11 June 1998 (1998-06-11)	1-3, 7-9
A	the whole document	4-6
Y	GB 2 328 594 A (MOTOROLA INC) 24 February 1999 (1999-02-24) page 5, line 20 -page 7, line 16	1-3, 7-9
A	US 5 381 423 A (TURCO ERMANN) 10 January 1995 (1995-01-10) the whole document	1-9

☐ Further documents are listed in the continuation of box C.☒ Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- "&" document member of the same patent family

Date of the actual completion of the international search

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Name and mailing address of the ISA

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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Application No

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9825350 A	11-06-1998	US 5936978 A AU 5518398 A BR 9713858 A CN 1245599 A EP 0944963 A	10-08-1999 29-06-1998 14-03-2000 23-02-2000 29-09-1999
GB 2328594 A	24-02-1999	US 6009552 A CN 1208997 A FR 2765749 A JP 11234142 A	28-12-1999 24-02-1999 08-01-1999 27-08-1999
US 5381423 A	10-01-1995	DE 69004801 D DE 69004801 T WO 9101598 A EP 0484412 A	05-01-1994 16-06-1994 07-02-1991 13-05-1992

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT



(PCT Article 36 and Rule 70)

Applicant's or agent's file reference ...	FOR FURTHER ACTION		See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/EP00/07308	International filing date (day/month/year) 28/07/2000	Priority date (day/month/year) 30/07/1999	
International Patent Classification (IPC) or national classification and IPC H03M13/00			
Applicant TELIT MOBILE TERMINALS S.P.A.			

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.
- ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).
- These annexes consist of a total of 4 sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 31/01/2001	Date of completion of this report 26.10.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Farman, T Telephone No. +49 89 2399 2246 

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/EP00/073

I. Basis of the report

1. With regard to the elements of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1,2,4-14	as originally filed	
3	with telefax of	12/10/2001

Claims, No.:

1-9	with telefax of	12/10/2001
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Drawings, sheets:

1/4-4/4	as originally filed
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2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure of the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT**

International application No. PCT/EP00/07308

- ☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-9
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-9
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-9
	No:	Claims	

- 2. Citations and explanations**
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

**INTERNATIONAL PRELIMINARY
EXAMINATION REPORT - SEPARATE SHEET**

International application No. PCT/EP00/07308

Concerning Section V

Document D1 discloses a method for decoding a shortened Fire code capable of decoding one burst of error, for example the (224, 184) Fire code used in the GSM communication protocol, which is capable of decoding a 12-bit error burst.

The claimed invention provides for the additional correction of a second error burst shorter than the first burst by using a lookup table storing correction values for specific syndrome values.

This concept is neither disclosed nor suggested in the available prior art.

Concerning section VIII

Claim 7 is not clear (Article 6 PCT) for the following reasons:

Claim 7, which is an apparatus claim, comprises features formulated as method features.

Moreover, the characterising portion of claim 7 is not grammatically correct, thus rendering its understanding unduely complicated.

highly probably that on the 224 bit block of information transmitted there will appear two bursts. If in the received word there is another error sequence or burst in addition to the 12 bit one expected in the prior art, the conventional Fire standard decoder is not able to correct the received word and return it to the correct transmitted value. In practice it happens that, under relatively disturbed transmission conditions, conventional decoders supply errors at output with unacceptable frequency.

10 The general purpose of the present invention is to remedy the above mentioned shortcomings by making available a method and an apparatus for decoding numerical signals codified with Fire codes which would allow correction within a given block of even two error sequences to return

15 the output errors to an acceptable value even with high interference on the transmission channel.

In view of this purpose it was sought to provide in accordance with the present invention a decoding method with error correction of a cyclic code signal $r(x)$

20 containing a main error burst shorter than or equal to a number n and a secondary error burst shorter than or equal to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions with the cyclic code

25 being a shortened Fire code to supply at most a standard correction of a single burst shorter than or equal to n and comprising the steps of:

- calculation of a predetermined number of syndromes S generable in an error burst having pattern P of length k

CLAIMS

1. Method for decoding with error correction of a cyclic code signal $r(x)$ containing a main error burst shorter than or equal to a number n and a secondary error burst shorter than or equal to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions with the cyclic code having a shortened Fire code to supply at most standard correction of a single burst shorter than or equal to n comprising the steps of:
- calculation of a predetermined number of syndromes S generable in an error burst having pattern P of length k and position X within the signal;
 - memorizing in a table the syndromes S calculated and associating them with a respective pattern P and the respective position X ;
- and for every signal $r(x)$ received:
- calculating for the signal received $r(x)$ the corresponding syndrome $S(x)$,
 - seeking the sequence of the first n bits of the syndrome $S(x)$ among the predetermined number of syndromes in the table and, if traced,
 - correcting the secondary burst on the basis of the pattern P and the position X associated in the table with the syndrome which was found therein and then correcting the primary burst.
2. Method in accordance with claim 1 comprising, if the search in the table has a negative outcome, the further

step of calculating for the signal $r(x)$ the rotated syndrome and employing this rotated syndrome to perform a new search.

3. Method in accordance with claim 1 in which correction of the primary error is done by employing a syndrome obtained by adding the present syndrome to the syndrome traced in the table.

4. Method in accordance with claim 1 comprising the further step of performing concluding verification that the corrected signal is a code word recalculating the syndrome.

5. Method in accordance with claim 1 in which $k=4$.

6. Method in accordance with claim 1 in which the Fire code is a shortened Fire code (224,184).

7. Apparatus for decoding with error correction of a cyclic code signal $r(x)$ containing a main error burst shorter than or equal to a number n and a secondary error burst shorter than or equal to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions and the cyclic code being a shortened Fire code to supply at most standard correction of a single burst shorter than or equal to n characterized in that it comprises:

- a memory (218) memorizing a predetermined number of syndromes S generable in an error burst having pattern P of length k and position X within the signal,
- a calculation unit (211) receiving at input the received signal $r(x)$ and calculating the corresponding syndrome $S(x)$, and

- a comparison unit (213) which verifies the status of the calculated syndrome bits and on the basis thereof emits towards a calculation and correction unit (217) a signal of no error, main error burst presence, or secondary error

5 burst presence,

with the calculation and correction unit (217) seeking among the syndromes memorized in the memory (218) the sequence of the first n bits of the syndrome $S(x)$ and if it finds it correcting the secondary burst on the basis of the
10 relative position X of the error and the pattern P associated in the table and then correcting the primary burst.

8. Apparatus in accordance with claim 7 characterized in that if the search in the memory (218) has a negative
15 outcome the calculation unit calculates for the signal $r(x)$ the rotated syndrome and employs this rotated syndrome to perform a new search in the memory.

9. Apparatus in accordance with claim 7 characterized in that the calculation unit employs for correction of the
20 primary error a syndrome obtained by adding together the present syndrome and the syndrome traced in the memory.

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(71) Applicant (*for all designated States except US*): **TELIT MOBILE TERMINALS S.P.A.** [IT/IT]; Viale Stazione di Prosecco, 5/b, I-34010 Sgonico (IT).

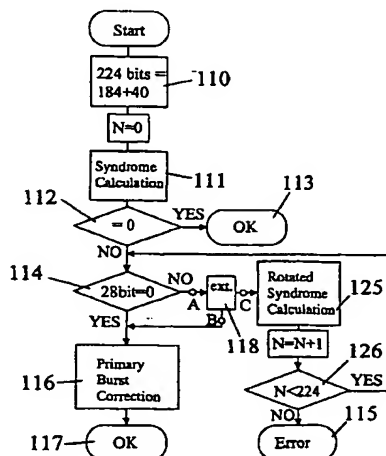
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(75) Inventors/Applicants (*for US only*): **PUPOLIN, Silvano** [IT/IT]; Via Rismondo, 4, I-30173 Venezia-Mestre (IT). **VENTURATO, Lorenzo** [IT/IT]; Via Baruzzi, 22, I-35129 Padova (IT). **TONETTO, Daniele** [IT/IT]; Via Tram, 7/A, I-30016 Jesolo (IT).

(54) Title: **METHOD AND APPARATUS FOR CORRECTION OF ERRORS IN FIRE CODES USED IN GSM CONTROL CHANNELS**



(57) Abstract: Method and device for decoding with error correction of a cyclic code signal $r(x)$ containing a main error burst shorter than or equal to a number n and a secondary error shorter than or equal to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions with the cyclic code being a shortened Fire code to supply at most a standard correction of a single burst shorter than or equal to n . According to the method the error burst correction algorithm originally proposed by Fire but modified with the error trapping procedure based on recognition of first k bits of the syndrome generated by the secondary bursts is used jointly.

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"Method and apparatus for correction of errors in Fire codes used in GSM control channels"

The present invention relates to the field of error
5 correction in numerical transmissions and in particular to
a method and an apparatus for more efficient error
correction with shortened Fire codes. This is particularly
useful in control channels for GSM cellular telephony.
Conventional high speed data communication systems commonly
10 use cyclic error detection codes to detect and correct data
received with transmission errors. These errors can be
caused by the number of transmission disturbance types such
as evanescence, channel noise, interference et cetera. One
class of particularly well known cyclic codes used is known
15 by the code name 'Fire'. These codes can be advantageously
used for correction of transmission channel error bursts.
An error burst is a long sequence of mistaken symbols
included between the first and last mistaken bits in the
transmitted word.
20 A coded word or sequence $r(x)$ received can be expressed as
the sum of the correct sequence transmitted $c(x)$ and the
mistaken bit configuration $e(x)$. As $r(x)$ can be considered
a single polynomial, a single syndrome can be calculated
therefrom by scrolling the received word in one direction
25 and the errors can be corrected by scrolling the received
word in the opposite direction. Correction is based on the
consideration that with a certain number of cyclic scrolls
of the word received it is possible to isolate the error
burst in the n final bits of the syndrome. A decoder

therefore operates by calculating the syndrome for each scrolling cycle of the received word and when it determines that the first $l-n$ bits of the syndrome (where l = syndrome length) are zero then the remaining n bits of the syndrome represent the error burst in the received word. These errors can be corrected by scrolling the received word of the corresponding number of bits in the opposite direction. To define the type of Fire coding used, a notation (n,k) is used where the number n represents the length of the information word and the number k the length of the corresponding Fire error correction code. In the Fire standard these numbers are very high with a coded word having length $n+k=3014633+3014593$. In many applications such a word length is not acceptable because it is too high for practical systems. Accordingly shortened Fire codes were introduced. By shortening the Fire code however a limitation concerning the greatest error burst length which can be corrected is introduced.

For example, in accordance with the GSM communication protocol the control channels are subject to dual coding, internal with $\frac{1}{2}$ rate convolution code $(456, 228)$ and external with shortened Fire code $(224,184)$. Decoding the shortened Fire code is effective for correcting an error burst less than or equal to 12 bits long. But this is not always sufficient.

For example, from an attentive examination of the error sequences produced in the convolutional code decoding the filer of this application reached the conclusion that for radio channel error probability between 10^{-2} e 10^{-1} it is

highly probably that on the 224 bit block of information transmitted there will appear two bursts. If in the received word there is another error sequence or burst in addition to the 12 bit one expected in the prior art, the conventional Fire standard decoder is not able to correct the received word and return it to the correct transmitted value. In practice it happens that, under relatively disturbed transmission conditions, conventional decoders supply errors at output with unacceptable frequency.

10 The general purpose of the present invention is to remedy the above mentioned shortcomings by making available a method and an apparatus for decoding numerical signals codified with Fire codes which would allow correction within a given block of even two error sequences to return the output errors to an acceptable value even with high interference on the transmission channel.

In view of this purpose it was sought to provide in accordance with the present invention a decoding method with error correction of a cyclic code signal $r(x)$

20 containing a main error burst shorter than or equal to a number n and a secondary error burst shorter than or equal to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions with the cyclic code being a shortened Fire code to supply at most a standard correction of a single burst shorter than or equal to n and comprising the steps of:

25 - calculation of a predetermined number of syndromes S generable in an error burst having pattern P of length k

and position X within the signal;

- memorizing in a table the syndromes S calculated and associating them with a respective pattern P and the respective position X ;

5 and for every signal $r(x)$ received:

- calculating for the signal received $r(x)$ the corresponding syndrome $S(x)$,

seeking the sequence of the first n bits of the syndrome $S(x)$ between the predetermined number of syndromes in the

10 table and, if traced,

- correcting the secondary burst on the basis of the pattern P and the position X associated in the table with the syndrome which was found therein and then correcting the primary burst.

15 Again in accordance with the principles of the present invention it was sought to provide a decoding apparatus for decoding with error correction of a cyclic code signal $r(x)$ containing a main error burst shorter than or equal to a number n and a secondary error burst shorter than or equal
20 to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions and the cyclic code being a shortened Fire code to supply at most standard correction of a single burst shorter than or equal to n characterized
25 in that it comprises:

- a memory (218) memorizing a predetermined number of syndromes S generable in an error burst having pattern P of length k and position X within the signal,

a calculation unit (211) receiving at input the received signal $r(x)$ and calculating the corresponding syndrome $S(x)$, and

- a comparison unit (213) which verifies the status of the
5 calculated syndrome bits and on the basis thereof emits towards a calculation and correction unit (217) a no error signal, main error burst presence, secondary burst error presence,

with the calculation and correction unit (217) seeking
10 among the syndromes memorized in the memory (218) the sequence of the first n bits of the syndrome $S(x)$ and, if it finds it, correcting the secondary burst on the basis of the relative position X of the error and of the pattern P associated in the table and then correcting the primary
15 burst.

To clarify the explanation of the innovative principles of the present invention and its advantages compared with the prior art there is described below with the aid of the annexed drawings possible embodiments thereof by way of
20 non-limiting examples applying said principles. In the drawings:

- FIG 1 is a flowchart of the prior art error correction method with Fire code,
- FIG 2 is a flowchart of the error correction method with
25 Fire code provided in accordance with the innovative principles of the present invention,
- FIG 3 is a more detailed flowchart of a part of the chart of FIG 2,

- FIG 4 shows diagrammatically the possible relative position of two error bursts,
- FIG 5 shows a correlation table in accordance with the present invention, and

- 5 - FIG 6 shows a block diagram of an apparatus applying the method in accordance with the present invention.

With reference to the figures there are described below a method and a decoding apparatus for correction of errors with improved Fire codes to assure correct decoding even
10 under conditions which cannot be handled by conventional systems.

The shortened Fire code (224,184) employed in normal GSM transmissions is able to correct a single error burst (i.e. a sequence included between the first and last mistaken
15 bits in a code word) at most 12 bits long. The Fire code is also able to detect but not correct the presence of error bursts longer than 12 bits.

As mentioned in the introduction it was found that in even moderately noisy channels there is a high probability that
20 on the length of a 224 bit code word there will be two error bursts which the standard Fire decoder is not able to correct. The innovative decoder provided in accordance with the principles of the present invention is able to confront and correct even these cases.

25 FIG 1 shows a flow diagram for error correction in accordance with the prior art. As may be seen in the figure, once the 224 bit sequence making up the code word (made up of 184 bits of information and 40 bits for parity control) is received in 10, the syndrome rotated relativ

to W cyclic rotations of the input polynomial with
W=3.014.438 (block 11) is calculated. Then whether the 40
bit syndrome is made up of zeroes only is verified in 12.
If it is, there are no errors in the received sequence and
5 the correction procedure terminates correctly in 13. If on
the contrary not all the 40 bits of the syndrome are zero
it means that there are errors in the received sequence.
In this latter case it is verified in 14 whether at least
the first 28 bits of the syndrome are zero (i.e. the
10 received signal contains at most 12 mistakes) which is the
indispensable condition for application of the standard
correction procedure with shortened Fire code.

If the first 28 bits are zero, the errors (which are shown
in the 12 not zero bits) are correctable by applying the
15 standard correction method in block 16, a method well known
to those skilled in the art and therefore not further
described herein, to have the correct sequence at the
output 17.

If the first 28 bits of the syndrome are not all zeroes
20 block 25 calculates the rotated syndrome to verify
(returning to block 14) whether it is possible to find a
rotated syndrome having 28 zero bits. The procedure
terminates in 17 with the corrected word if on rotation the
syndrome with 28 zero bits is found or terminates in 15
25 with an uncorrectable error signal if after performing all
the 224 possible rotations no syndrome with 28 zero bits is
found.

In other words the known decoding procedure verifies
whether there is a 40 bit syndrome calculated for one of

the 224 translations of the vector $r(x)$ received and made up of 28 zeros followed by 12 not zero bits and, if it finds it, corrects the vector $r(x)$ accordingly. If on the contrary in the 224 translations it is not possible to find a syndrome with 28 zero bits it means that in the received word there is another error sequence and in this case with application of the standard method only the decoder cannot do other than signal the error (output 15 = uncorrectable error), without any possibility of correcting it.

FIG 2 shows a flowchart similar to the one in FIG 1 but providing the method in accordance with the present invention.

In the initial stages the method in accordance with the present invention is similar to the known standard method.

Indeed, as may be seen in FIG 2, once the 224 bit sequence constituting the code word is received, the syndrome is calculated in block 111 and it is verified whether it is made up of zeroes only. If so, there are no errors in the received sequence and the correction procedure terminates normally in 113. If not all 40 bits of the syndrome are zero it is verified (block 114) whether at least the first 28 bits of the syndrome are zero, which is the indispensable condition for application of the normal correction procedure (block 116) and obtain therewith the correct sequence in the outlet 117.

If the condition of having syndromes with 28 zero bits does not occur, instead proceeding immediately with calculation of a new rotated syndrome as took place in FIG 1 we go to a block 118 which will be called 'extended correction block'.

As will be seen, extended correction in accordance with the present invention also permits correcting a second burst of shorter length which we shall call secondary burst. By short lengths is meant a length k shorter than the length of the primary burst.

As seen in FIG 2 the extended correction block 118 receives in A the mistaken sequence (which can contain two error bursts: a primary and a secondary) and renders in B the sequence with the correct secondary burst error so that the primary burst error can be corrected by block 116. Block 118 also has an output C which is reached when an expected secondary burst proves to be outside the coded word, i.e. when the error sequence is not the one expected and therefore it is necessary to go on to the following syndrome rotation to then go back over the algorithm starting from the comparison 114.

FIG 3 shows in greater detail operation of the extended correction block 118 in accordance with the present invention. Operation of this block is based on the consideration that for sufficiently small secondary error bursts of length k the number of possible syndromes because of this 'secondary' error is sufficiently small to enable advance calculation and memorization of all the possible syndromes associated with the respective error patterns and positions so as to be able to perform an exhaustive search among these possible secondary burst syndromes to check whether the sequence of the first 28 not zero bits of the syndrome calculated on the received sequence is found among

the first 28 bits of one of the syndromes corresponding to the secondary burst of at most k bits.

If the syndrome is found in the table (look-up table) 120, we go on (block 122) to correction of the secondary burst

5 on the basis of the pattern and the relative position of the error (associated in the table with the syndrome) and then the syndrome (block 124) is also corrected so as to reach point B with a new syndrome which has its first 28 bits zero. This permits correcting the primary burst error
10 in 116 and coming out in 117 with the correct word.

If the syndrome is not found in the table, from block 122 we go on to point C to recycle with a new rotated syndrome as explained above. Only if secondary burst correction is not possible for any of the possible syndrome rotations we
15 come out in 115 with 'uncorrectable error'. The frequency with which we reach the output 115 is much less than that with which the standard method of FIG 1 reaches the corresponding output 15.

To define the relationship of length k on the dimension of
20 the table 120 and, in conclusion, give a decision parameter concerning the expediency of performing the correction with the method of the present invention on the basis of a datum k , let it suffice to consider that if the second error sequence is made up of a burst not longer than k
25 consecutive bits, the relative position compared with the 228 bit burst may prove in the two extreme cases to be as shown in FIG 4. The relative positions of the two bursts are therefore equal to $2(216-k)=432-2k$ error sequences. The syndromes generated by the sequence of k mistaken bits

are thus $(432-2k)(2^k-1)$ and the complexity in the calculation thereof depends accordingly on 2^k ; k is to be selected according to the memory available in the receiver for table memorization.

- 5 A value of $k=4$ was found to give and advantageous corrected error/computing cost ratio and dimensions of the table for GSM transmissions. With $k=4$ there are $424 \times 15 = 6360$ syndromes, which is an acceptable number to be able to proceed with use of the method in accordance with the
- 10 present invention even with the relatively small calculating power and quantity of memory normally employed in conventional cellular telephones. Naturally k can be increased by increasing the performance of the hardware used.
- 15 FIG 5 shows diagrammatically the structure of table 120. It is made up of three columns and n_s rows where n_s is the number of possible syndromes generable from a sequence of k mistaken bits. As mentioned, in the particular case of $k=4$ it is $n_s=6360$. In the first column of the table are
- 20 memorized all the possible syndromes S , in the second column is memorized the associated error pattern P of k bits for each of these, and in the third column is memorized the associated position X of the error.
- Essentially, to create the table it suffices to consider
- 25 all the possible positions and error patterns and calculate the relative syndrome for each combination.
- For convenience and speed of search, in the table it is advantageous to memorize the syndromes ordered on the basis of their first 28 bits.

In this method it is easy to trace (block 121,122) in the look-up table whether the sequence of the first 28 bits (not zero) of the syndrome calculated on the sequence received is found in the first 28 bits of one of the

5 syndromes corresponding to the secondary burst of at most k bits and that are memorized in the look-up table.

If the syndrome corresponds to a possible error sequence we proceed to correction and then verify whether the correct sequence is a valid code sequence or not. This is because

10 the syndrome could correspond to another error sequence.

It was noted that there are some secondary burst sequences which give rise to the same first 28 bits. For these sequences it is accordingly not distinguishable which of the possible code words was really transmitted. To avoid

15 accepting a mistaken word as correct it was preferred to discard these sequences, not inserting them in the look-up table so that not all secondary bursts are correctable.

Since the number of sequences to be discarded is very limited compared to the total number of sequences (e.g. the

20 number of sequences to be discarded for $k=4$ was seven) giving up their correction is acceptable.

To correct the secondary burst, in block 123 the bits of the signal $r(x)$ indicated by the pattern P and which are in position X where P and X are those associated with the

25 syndrome found in the table are inverted. In addition correction of the syndrome is performed in block 124 by merely adding the present syndrome (at point A) to the syndrome of the table. The result of the sum is a new syndrome with the first 28 bits zero (since by definition

the table syndrome was the one associated with the error which had produced the first 28 not zero bits in the syndrome which had been calculated on the signal and possibly rotated).

5 Since at outlet B of block 118 the syndrome certainly has the first 28 bits zero, it is possible to return downstream from the control block 114 to avoid a useless verification. It is now clear to those skilled in the art that the predetermined purposes have been achieved by making
10 available a method permitting error correction in Fire codes even for sequences containing two error bursts by using a correction algorithm of error bursts such as the one originally proposed by Fire but changing with the error trapping procedure based on recognition of the first (in
15 the specific case) 28 bits of the syndromes generated by the secondary bursts.

FIG 5 shows a block diagram of a receiving apparatus employing the method of the present invention. This apparatus receives the sequence $r(x)$ which is memorized in
20 the memory block 210. A calculating block 211 for the syndrome calculates the syndrome $S(x)$ and memorizes it in memory block 212. A comparison block 213 verifies whether all the first 40 bits or only the first 28 bits are zero and emits corresponding signals 214, 215 and 216 indicating
25 respectively whether no correction is required (first 40 bits zero), correction of a secondary burst is required (first 28 bits other than zero) or whether correction of the primary burst (first 28 bits zero) is required. The calculating unit 217 (which memorizes the look-up table of

the possible syndromes in the memory 218) performs the required corrections and if necessary recycles the syndrome until the correct signal $g(x)$ is obtained at output.

Naturally the above description of an embodiment applying
5 the innovative principles of the present invention is given by way of non-limiting example of said principles within the scope of the exclusive right claimed here.

Those skilled in the art can readily imagine how to provide a similar apparatus for applying the described method in
10 practice, e.g. by implementing it with software in a Digital Signal Processor (DSP) or providing it in cabled logic with appropriate electronic components.

CLAIMS

1. Method for decoding with error correction of a cyclic code signal $r(x)$ containing a main error burst shorter than or equal to a number n and a secondary error burst shorter than or equal to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions with the cyclic code having a shortened Fire code to supply at most standard correction of a single burst shorter than or equal to n comprising the steps of:
- calculation of a predetermined number of syndromes S generable in an error burst having pattern P of length k and position X within the signal;
 - 15 - memorizing in a table the syndromes S calculated and associating them with a respective pattern P and the respective position X ;
- and for every signal $r(x)$ received:
- calculating for the signal received $r(x)$ the corresponding syndrome $S(x)$,
 - 20 - seeking the sequence of the first n bits of the syndrome $S(x)$ among the predetermined number of syndromes in the table and, if traced,
 - correcting the secondary burst on the basis of the pattern P and the position X associated in the table with the syndrome which was found therein and then correcting the primary burst.
 - 25
2. Method in accordance with claim 1 comprising, if the search in the table has a negative outcome, the further

step of calculating for the signal $r(x)$ the rotated syndrome and employing this rotated syndrome to perform a new search.

3. Method in accordance with claim 1 in which correction of
5 the primary error is done by employing a syndrome obtained by adding the present syndrome to the syndrome traced in the table.

4. Method in accordance with claim 1 comprising the further
10 step of performing concluding verification that the corrected signal is a code word recalculating the syndrome.

5. Method in accordance with claim 1 in which $k=4$.

6. Method in accordance with claim 1 in which the Fire code
is a shortened Fire code (224,184).

7. Apparatus for decoding with error correction of a cyclic
15 code signal $r(x)$ containing a main error burst shorter than or equal to a number n and a secondary error burst shorter than or equal to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions and the
20 cyclic code being a shortened Fire code to supply at most standard correction of a single burst shorter than or equal to n characterized in that it comprises:

- a memory (218) memorizing a predetermined number of syndromes S generable in an error burst having pattern P of
25 length k and position X within the signal,
a calculation unit (211) receiving at input the received signal $r(x)$ and calculating the corresponding syndrome $S(x)$, and

- a comparison unit (213) which verifies the status of the calculated syndrome bits and on the basis thereof emits towards a calculation and correction unit (217) a signal of no error, main error burst presence, or secondary error

5 burst presence,

with the calculation and correction unit (217) seeking among the syndromes memorized in the memory (218) the sequence of the first n bits of the syndrome $S(x)$ and if it finds it correcting the secondary burst on the basis of the
10 relative position X of the error and the pattern P associated in the table and then correcting the primary burst.

8. Apparatus in accordance with claim 7 characterized in that if the search in the memory (218) has a negative
15 outcome the calculation unit calculates for the signal $r(x)$ the rotated syndrome and employs this rotated syndrome to perform a new search in the memory.

9. Apparatus in accordance with claim 7 characterized in that the calculation unit employs for correction of the
20 primary error a syndrome obtained by adding together the present syndrome and the syndrome traced in the memory.

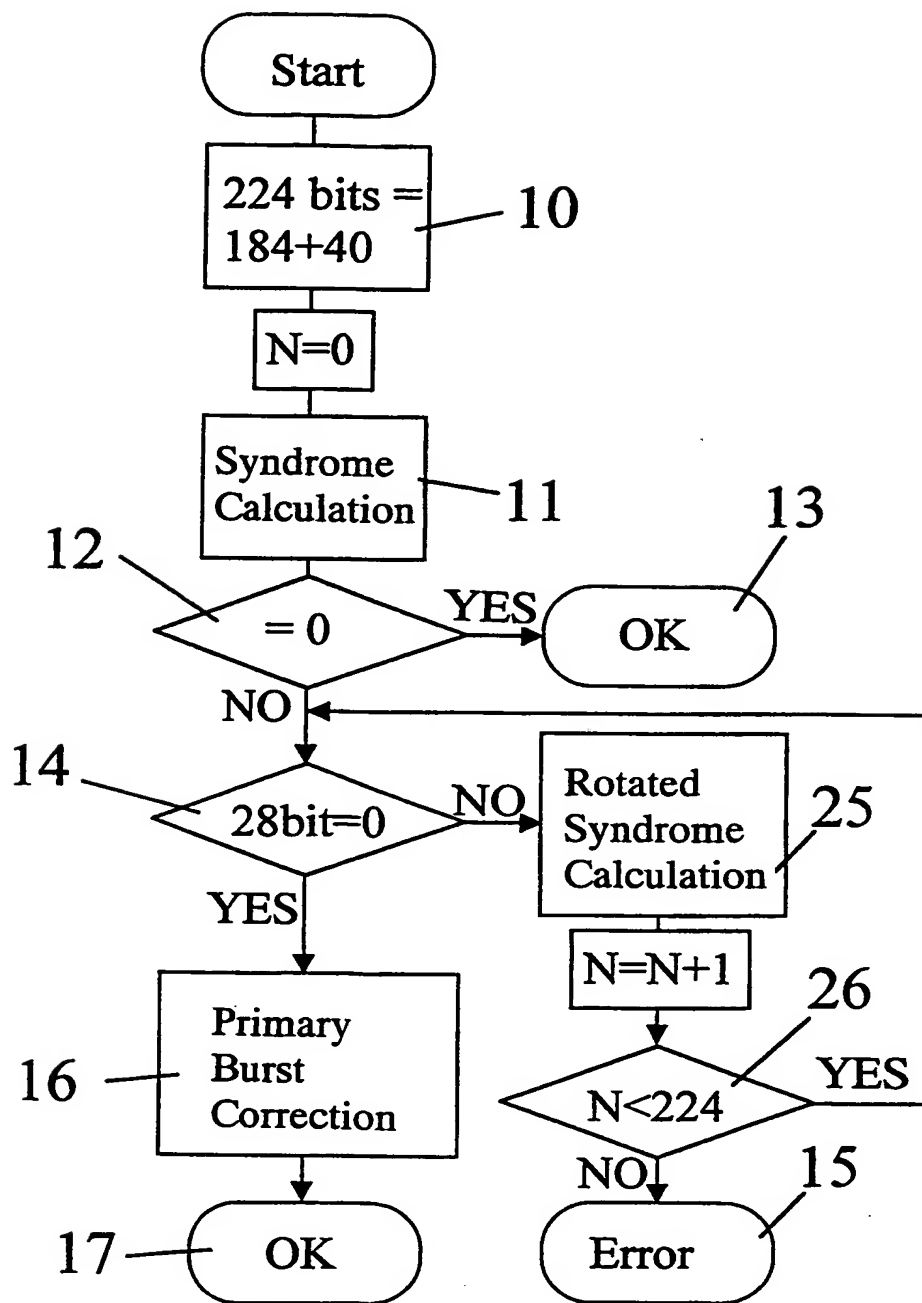


Fig.1

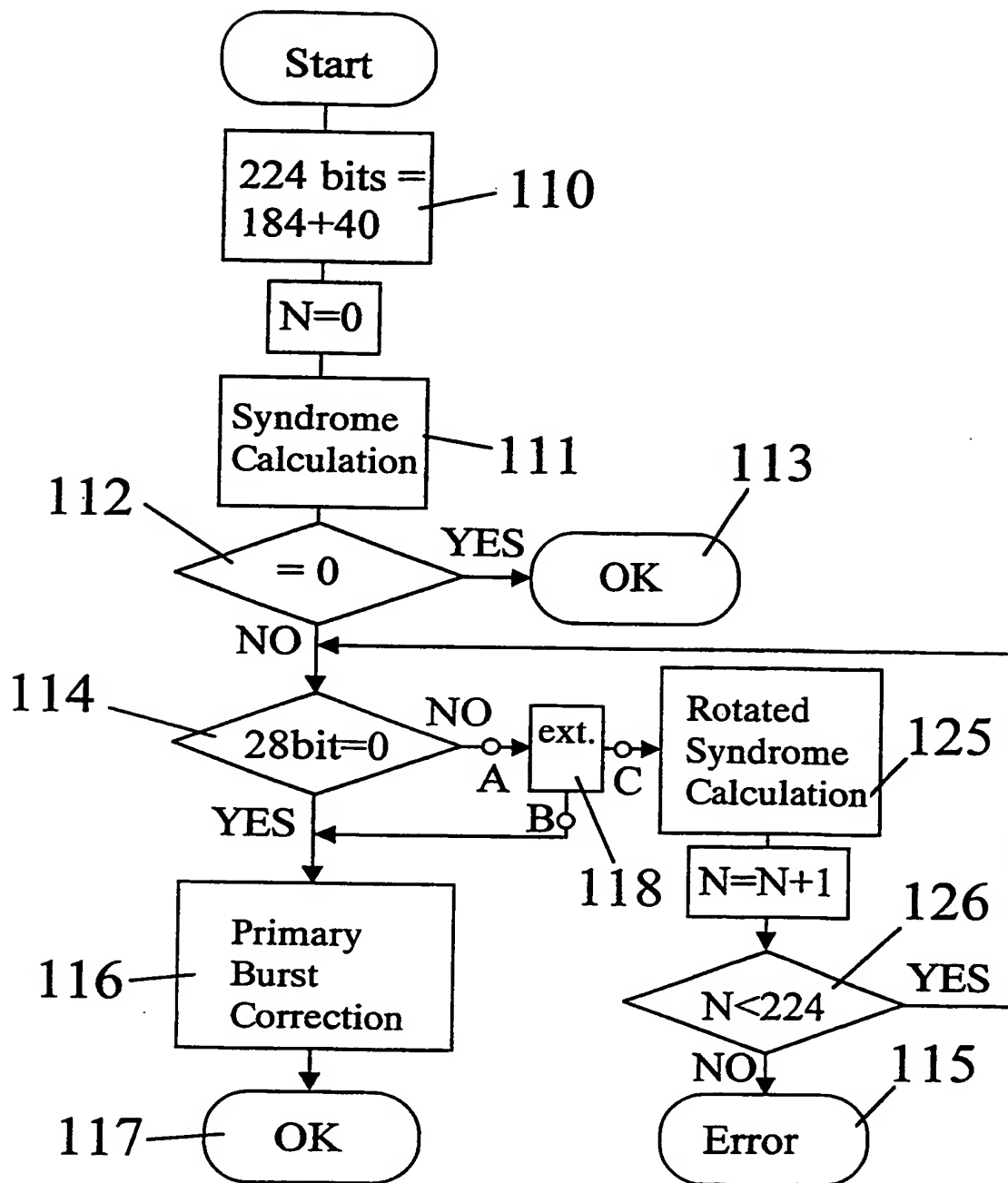


Fig.2

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REC'D 31 OCT 2001

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference ...	FOR FURTHER ACTION See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/EP00/07308	International filing date (day/month/year) 28/07/2000	Priority date (day/month/year) 30/07/1999
International Patent Classification (IPC) or national classification and IPC H03M13/00		
Applicant TELIT MOBILE TERMINALS S.P.A.		



- This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.
- This REPORT consists of a total of 4 sheets, including this cover sheet.

☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

 These annexes consist of a total of 4 sheets.

- This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☐ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand 31/01/2001	Date of completion of this report 26.10.2001
Name and mailing address of the international preliminary examining authority:  European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Farman, T Telephone No. +49 89 2399 2246 

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/07308

I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

Description, pages:

1,2,4-14 as originally filed
3 with telefax of 12/10/2001

Claims, No.:

1-9 with telefax of 12/10/2001

Drawings, sheets:

1/4-4/4 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/EP00/07308

- ☐ the description, pages:
☐ the claims, Nos.:
☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-9
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-9
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-9
	No:	Claims	

2. Citations and explanations
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

Concerning Section V

Document D1 discloses a method for decoding a shortened Fire code capable of decoding one burst of error, for example the (224, 184) Fire code used in the GSM communication protocol, which is capable of decoding a 12-bit error burst.

The claimed invention provides for the additional correction of a second error burst shorter than the first burst by using a lookup table storing correction values for specific syndrome values.

This concept is neither disclosed nor suggested in the available prior art.

Concerning section VIII

Claim 7 is not clear (Article 6 PCT) for the following reasons:

Claim 7, which is an apparatus claim, comprises features formulated as method features.

Moreover, the characterising portion of claim 7 is not grammatically correct, thus rendering its understanding unduely complicated.

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3

- highly probably that on the 224 bit block of information transmitted there will appear two bursts. If in the received word there is another error sequence or burst in addition to the 12 bit one expected in the prior art, the
- 5 conventional Fire standard decoder is not able to correct the received word and return it to the correct transmitted value. In practice it happens that, under relatively disturbed transmission conditions, conventional decoders supply errors at output with unacceptable frequency.
- 10 From the document WO 9825350 A is known a method of error correction for the shortened Fire code, using right cyclic shifts.
- An inconvenient of this method is that it is capable only of correcting one burst in codewords of length up to 12 bits.
- 15 The general purpose of the present invention is to remedy the above mentioned shortcomings by making available a method and an apparatus for decoding numerical signals codified with Fire codes which would allow correction within a given block of even two error sequences to return
- 20 the output errors to an acceptable value even with high interference on the transmission channel.
- In view of this purpose it was sought to provide in accordance with the present invention a decoding method with error correction of a cyclic code signal $r(x)$
- 25 containing a main error burst shorter than or equal to a number n and a secondary error burst shorter than or equal to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions with the cyclic code
- 30 being a shortened Fire code to supply at most a standard correction of a single burst shorter than or equal to n and comprising the steps of:
- calculation of a predetermined number of syndromes S generable in an error burst having pattern P of length k

AMENDED SHEET

Empfangszeit 12.01.1. 8:08

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CLAIMS

1. Method for decoding with error correction of a cyclic code signal $r(x)$ containing a main error burst shorter than or equal to a number n and a secondary error burst shorter than or equal to a number k where $k < n$ with the secondary error burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions, where the cyclic code comprises a shortened Fire code in order to allow a correction step of said main error burst shorter than or equal to n characterized by the steps of:

for every signal $r(x)$ received,

- calculating for the signal received $r(x)$ the corresponding syndrome $S(x)$,
- seeking the sequence of the first n bits of the syndrome $S(x)$ among the predetermined number of syndromes in a look-up table that contains memorized the calculation of a predetermined number of syndromes S generable in an error burst having pattern P of length k and position X within the signal, said syndromes S being associated with the respective pattern P and the respective position X ;

and, if an error burst is traced,

- correcting the secondary burst on the basis of the pattern P and the position X associated in the table with the syndrome $S(x)$ which was found therein,
- performing the correction step of the main error burst;

2. Method in accordance with claim 1 comprising, if the seek operation in the table has a negative outcome, the further step of calculating for the signal $r(x)$ the rotated syndrome and employing this rotated syndrome to perform a new seeking operation.

3. Method in accordance with claim 1 in which correction of the main error is done by employing a syndrome obtained by adding the present syndrome to the syndrome traced in the table.

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4. Method in accordance with claim 1 comprising the further step of performing concluding verification that the corrected signal is a code word recalculating the syndrome.
5. Method in accordance with claim 1 in which $k=4$.
6. Method in accordance with claim 1 in which the Fire code is a shortened Fire code (224,184).
7. Apparatus for decoding with error correction of a cyclic code signal $r(x)$ containing a main error burst shorter than or equal to a number n and a secondary error burst shorter than or equal to a number k where $k < n$ with the secondary burst causing in a syndrome $S(x)$ calculated on $r(x)$ the not zeroing of all the bits in the first n positions and the cyclic code being a shortened Fire code, said apparatus comprising a calculation unit (211) receiving at input said cyclic code signal $r(x)$ and calculating the corresponding syndrome $S(x)$, a comparison unit (213) which verifies the status of the calculated syndrome bits and on the basis thereof emits towards a calculation and correction unit (217) at least a signal of main error burst presence (216), said calculation and correction unit (217) performing the correction of the cyclic code signal $r(x)$ to output a correct signal $g(x)$, characterized in that the comparison unit (213) emits towards a calculation and correction unit (217) also secondary error burst presence, and in that a memory (218) memorizing a predetermined number of syndromes S generable in an error burst having pattern P of length k and position X within the signal, $S(x)$, and with the calculation and correction unit (217) seeks among the syndromes memorized in the memory (218) the sequence of the first n bits of the syndrome $S(x)$ and if it finds it outputs the correct signal $g(x)$ correcting the secondary burst on the basis of the relative position X of the error and the pattern P associated in the table and then correcting the primary burst.
8. Apparatus in accordance with claim 7 characterized in that if the search in the memory (218) has a negative outcome the calculation unit calculates for the signal

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r (x) the rotated syndrome and employs this rotated syndrom to perform a new search in the memory.

- 5 9. Apparatus in accordance with claim 7 characterized in that the calculation unit (217) employs for correction of the primary error a syndrome obtained by adding together the present syndrome and the syndrome traced in the memory.

AMENDED SHEET

Empfangszeit 17. Okt. 8:58

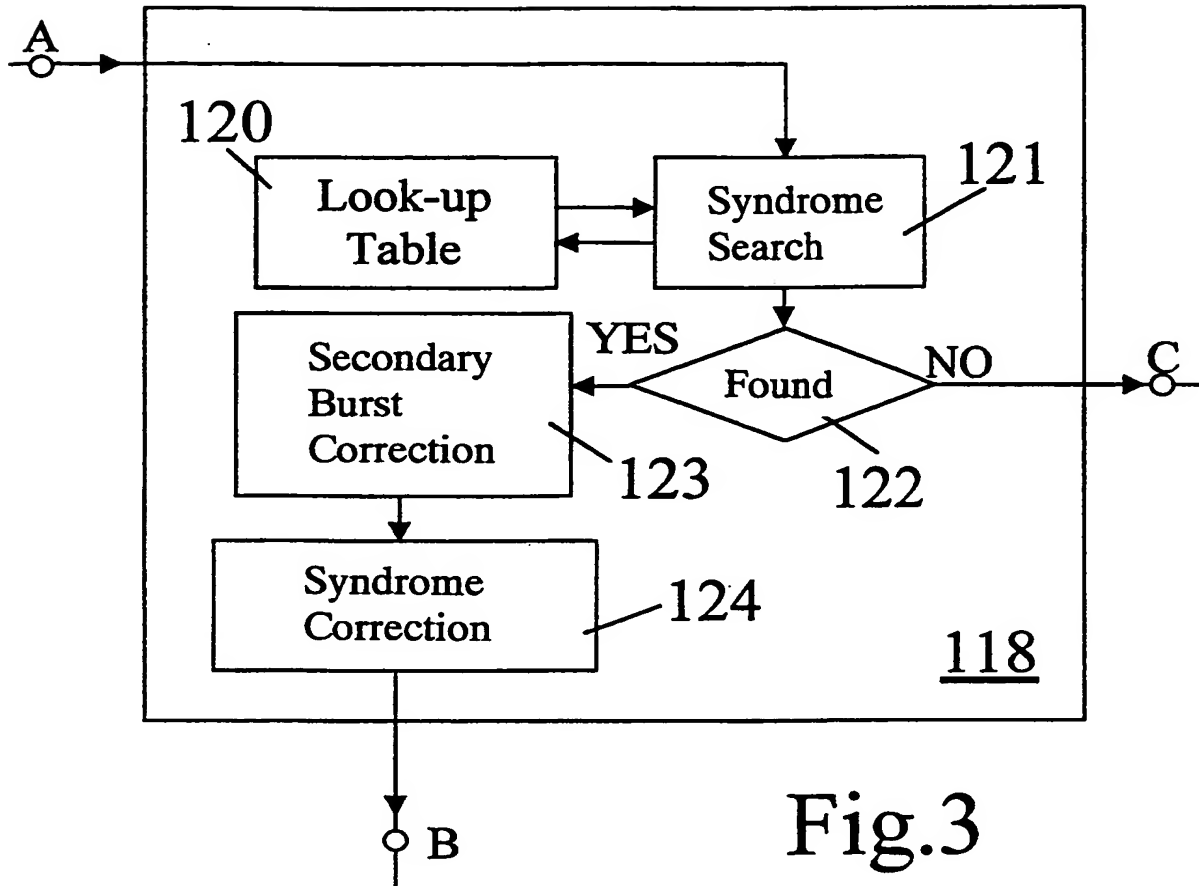


Fig.3

12 Mistakes	216-k bits	k
k	216-k bits	12 Mistakes

Fig.4

Syn.	Mist.	Item
S_1	P_a	X_a
S_2	P_b	X_b
S_{6360}	P_i	X_i

Fig.5

4/4

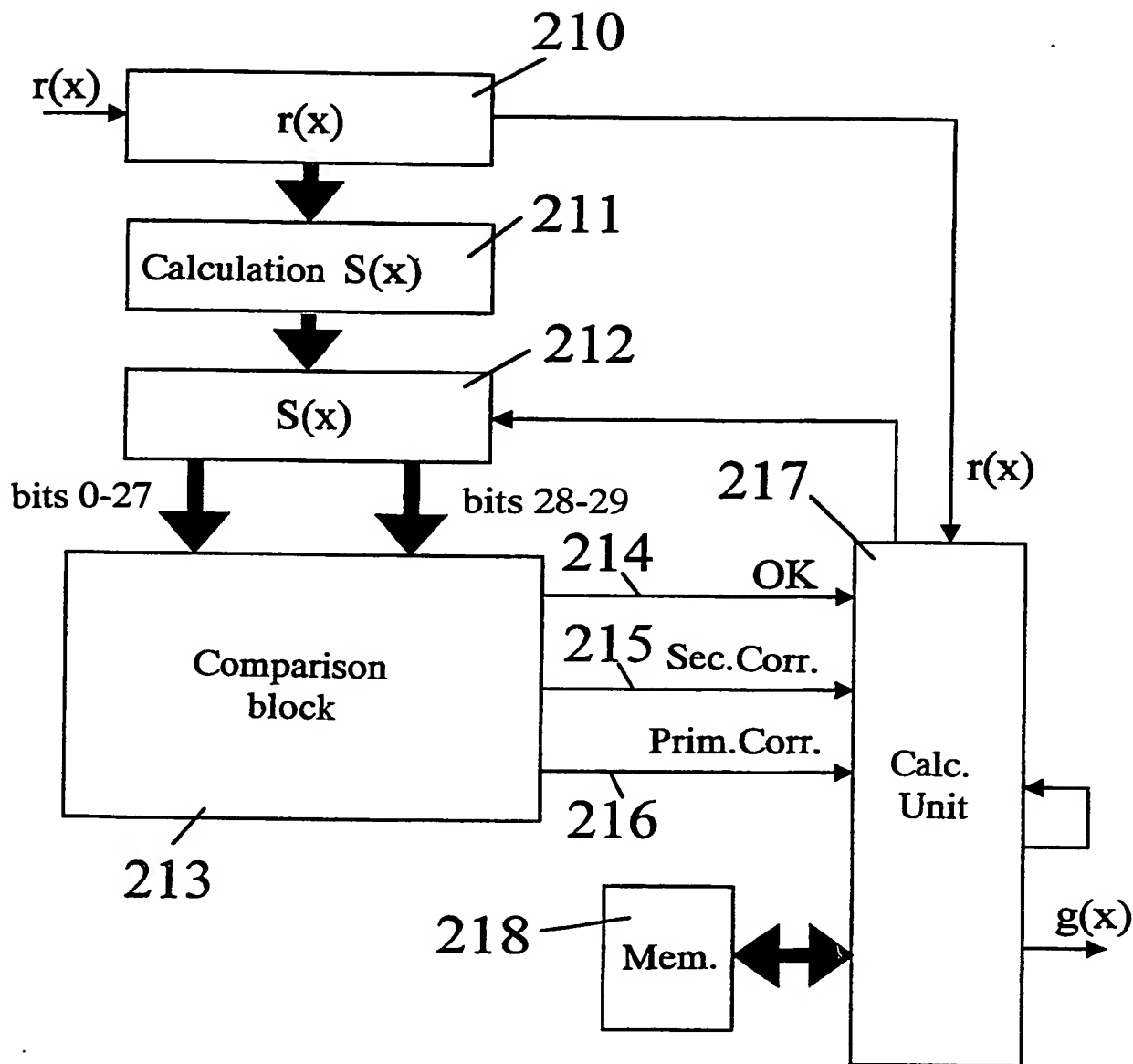


Fig.6

10/048198
JC10 Rec [redacted] /PTO 24 JAN 2002

The PTO did not receive the following
listed item(s)

No Postcard

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF THE RECORDING
OF A CHANGE(PCT Rule 92bis.1 and
Administrative Instructions, Section 422)

From the INTERNATIONAL BUREAU

To:

SCIRE, Giuseppe
Telit Mobile Terminals S.p.A.
Viale Stazione di Prosecco, 5/b
IT-34010 Sgonico
ITALIE

Date of mailing (day/month/year) 06 February 2001 (06.02.01)	IMPORTANT NOTIFICATION
Applicant's or agent's file reference 43055	
International application No. PCT/EP00/07308	International filing date (day/month/year) 28 July 2000 (28.07.00)

1. The following indications appeared on record concerning:									
<input type="checkbox"/> the applicant	<input type="checkbox"/> the inventor <input checked="" type="checkbox"/> the agent <input type="checkbox"/> the common representative								
Name and Address FARAGGIANA, Vittorio Ingg. Guzzi e Ravizza s.r.l. Via V. Monti, 8 IT-20123 Milano ITALY	<table border="1"> <tr> <td>State of Nationality</td> <td>State of Residence</td> </tr> <tr> <td colspan="2">Telephone No. 39-02-4816225/93</td> </tr> <tr> <td colspan="2">Facsimile No. 39-02-48008464</td> </tr> <tr> <td colspan="2">Teleprinter No.</td> </tr> </table>	State of Nationality	State of Residence	Telephone No. 39-02-4816225/93		Facsimile No. 39-02-48008464		Teleprinter No.	
State of Nationality	State of Residence								
Telephone No. 39-02-4816225/93									
Facsimile No. 39-02-48008464									
Teleprinter No.									
2. The International Bureau hereby notifies the applicant that the following change has been recorded concerning:									
<input type="checkbox"/> the person	<input type="checkbox"/> the name <input checked="" type="checkbox"/> the address <input type="checkbox"/> the nationality <input type="checkbox"/> the residence								
Name and Address SCIRE, Giuseppe Telit Mobile Terminals S.p.A. Viale Stazione di Prosecco, 5/b IT-34010 Sgonico ITALY	<table border="1"> <tr> <td>State of Nationality</td> <td>State of Residence</td> </tr> <tr> <td colspan="2">Telephone No. 040-41 92 111</td> </tr> <tr> <td colspan="2">Facsimile No. 040-25 11 11</td> </tr> <tr> <td colspan="2">Teleprinter No.</td> </tr> </table>	State of Nationality	State of Residence	Telephone No. 040-41 92 111		Facsimile No. 040-25 11 11		Teleprinter No.	
State of Nationality	State of Residence								
Telephone No. 040-41 92 111									
Facsimile No. 040-25 11 11									
Teleprinter No.									
3. Further observations, if necessary: Please note that the appointment of the agent has been revoked and that all further correspondence should be sent to the special address for correspondence as mentioned in Box 2.									
4. A copy of this notification has been sent to:									
<input checked="" type="checkbox"/> the receiving Office	<input checked="" type="checkbox"/> the designated Offices concerned								
<input checked="" type="checkbox"/> the International Searching Authority	<input type="checkbox"/> the elected Offices concerned								
<input type="checkbox"/> the International Preliminary Examining Authority	<input checked="" type="checkbox"/> other: FARAGGIANA, Vittorio								

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer N. Wagner
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
 US Department of Commerce
 United States Patent and Trademark
 Office, PCT
 2011 South Clark Place Room
 CP2/5C24
 Arlington, VA 22202
 ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing (day/month/year) 29 March 2001 (29.03.01)	
International application No. PCT/EP00/07308	Applicant's or agent's file reference 43055
International filing date (day/month/year) 28 July 2000 (28.07.00)	Priority date (day/month/year) 30 July 1999 (30.07.99)
Applicant PUPOLIN, Silvano et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:

31 January 2001 (31.01.01)

☐ in a notice effecting later election filed with the International Bureau on:2. The election ☒ was☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO 34, chemin des Colombettes 1211 Geneva 20, Switzerland	Authorized officer Nestor Santesso
Facsimile No.: (41-22) 740.14.35	Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference 43055	FOR FURTHER ACTION see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.	
International application No. PCT/EP 00/ 07308	International filing date (day/month/year) 28/07/2000	(Earliest) Priority Date (day/month/year) 30/07/1999
Applicant TELIT MOBILE TERMINALS S.P.A.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

☒ It is also accompanied by a copy of each prior art document cited in this report.

1. Basis of the report

a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

☐ contained in the international application in written form.

☐ filed together with the international application in computer readable form.

☐ furnished subsequently to this Authority in written form.

☐ furnished subsequently to this Authority in computer readable form.

☐ the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

☐ the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. ☐ **Certain claims were found unsearchable** (See Box I).

3. ☐ **Unity of invention is lacking** (see Box II).

4. With regard to the **title**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established by this Authority to read as follows:

5. With regard to the **abstract**,

☒ the text is approved as submitted by the applicant.

☐ the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No.

☒ as suggested by the applicant.

☐ because the applicant failed to suggest a figure.

☐ because this figure better characterizes the invention.

2

☐ None of the figures.

INTERNATIONAL SEARCH REPORT

International Application No

EP 00/07308

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 H03M13/17 H04L1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 7 H03M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, INSPEC, IBM-TDB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 98 25350 A (ERICSSON GE MOBILE INC) 11 June 1998 (1998-06-11)	1-3, 7-9
A	the whole document ---	4-6
Y	GB 2 328 594 A (MOTOROLA INC) 24 February 1999 (1999-02-24) page 5, line 20 -page 7, line 16 ---	1-3, 7-9
A	US 5 381 423 A (TURCO ERMANN) 10 January 1995 (1995-01-10) the whole document -----	1-9

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search

5 October 2000

Date of mailing of the international search report

12/10/2000

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

EP 00/07308

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
WO 9825350	A	11-06-1998	US 5936978 A	10-08-1999
			AU 5518398 A	29-06-1998
			BR 9713858 A	14-03-2000
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			CN 1208997 A	24-02-1999
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			DE 69004801 T	16-06-1994
			WO 9101598 A	07-02-1991
			EP 0484412 A	13-05-1992
